that the question is a grave one and that it should be faced before it is too late. We should try to avoid waste and unnecessary destruction and we should also try to make the best possible use of all of our resources. It will be the work of the engineer to accomplish both of these objects, and it will also be his province to determine new ways of accomplishing results now so wastefully performed. In the past the engineer has been concerned in getting results. If the results were obtained, the waste and destruction of the natural product have scarcely been considered, but in the future, economy of the natural product as well as economy in the final result must receive careful attention. I believe the engineers of the country are capable of solving these problems, and that if they are given the necessary governmental and private aid that the problem of the conservation of our natural resources will be solved.

The engineering colleges of the country will also have a share in this work. They are training the engineers of the future and from now on they must train them with this problem in view. They must not only give them the principles of engineering practise, but they must show them how the work of the engineer can be carried out with a view of transmitting to our posterity the natural resources in, so far as possible, an unimpaired condition. As has been pointed out in this paper, the conservation of some of our natural resources must be accomplished through new inventions. This means that the engineer of the future must be able to do more than the simple engineering work which comes to him from day to day. He must be so thoroughly trained in the principles of science and applied mechanics that he will be able to discover new processes and accomplish old results in new and more economical ways. He must be taught more thoroughly than ever before how to unite theoretical and practical knowledge. In short, he must be able to think along scientific and engineering lines. This is the most difficult thing which the engineering college has to teach. There are so many subjects in the curriculum, so much that is necessary for the engineer to learn, that he has not had the proper time to digest this mass of material. I feel convinced that this problem of teaching the student to think, of giving him the power to solve things for himself, has for many years received the earnest attention of the members of this society, but in view of the problem which I am discussing to-day, I wish to urge upon all who teach in our colleges the importance of giving it still more attention. Engineering science is progressive, the subjects taught in our engineering schools are alive and not dead. We shall grow, not only in knowledge, but in methods, and we shall accomplish the results we ought to accomplish and solve the problems presented to us.

Charles S. Howe
Case School of Applied Science,
Cleveland, Ohio

THE INCREASING IMPORTANCE OF THE RARER ELEMENTS[1]

In many of our courses in inorganic chemistry we have placed in view charts upon which the names of some eighty elementary substances appear. For one reason or another more than one half of these elements have remained to the majority of students little more than names; whereas to-day we find many of them contesting positions of importance with the better known elements on account either of industrial utility or of pure scientific interest. May I define then the rarer elements not as those necessarily rare in occurrence but rather as those not always

[1] Address of chairman of the Inorganic Section at the New Haven meeting of the American Chemical Society, June 30, 1908.

taken up in a general course in inorganic chemistry.

In considering briefly the reasons why it would seem best to remove at least a number of these elements from the confines of my definition I shall in general limit myself to the presentation of certain facts and figures gathered from the record of the last half-decade.

Hillebrand in discussing the analysis of silicate and carbonate rocks mentions Ti, Zr, V, Li, Ta, Cb, Be, Th, Ce, and the rare earths as possible ingredients of the silicate rocks, and adds in regard to Th, Ce and the rare earths that "they are probably more common as constituents of silicate rocks than has generally been supposed; and A. A. Noyes and his associates in their new system of qualitative analysis have included Tl, Pt, Au, Se, Te, Mo, Be, U, V, Ti and Zr.

For convenience the periodic grouping will be followed in the consideration of the elements which we wish to discuss.

In group (1) rubidium and cæsium clearly come under our definition, and possibly also lithium. Lithium, as already stated, is an ingredient to be reckoned with in rock analysis, while its importance in water analysis is shown by its presence in over forty samples of water from different parts of the world in amounts varying from traces to one per cent. In Clarke's data of geo-chemistry, from which these figures were taken, we find rubidium mentioned as present in about twenty samples of water, cæsium being more rare.

The last report of the United States Mineral Resources shows an output of about 2,200 short tons of lithium minerals since 1903 with a value of about $40,000.

During the past five years the greater part of the work upon these elements has been concerned with the formation of new compounds. It is perhaps of interest to note in this connection that iron alums of selenic acid containing cæsium and rubidium have been prepared, while the corresponding ammonium and potassium salts have not been successfully produced.

In group (2) we have the elements beryllium and radium. Concerning the former, I need add no word after the masterly paper upon "The Vagaries of Beryllium,"[2] given before this body a year ago by Chas. L. Parsons. To the student of pure chemistry, if not as yet to the technical chemist, the element offers most interesting problems. May we not hope that a more extended study of the production and properties of this metal of low specific gravity will make possible some important application in the arts.

It is not the purpose of this paper to take up the subject of radium and radioactivity more than to mention the stimulus which this branch of work has given to the study of uranium and thorium minerals and of their natural associates.

In group (3) we find yttrium and certain members of the cerium group. These bring us to the consideration of the rare earth group, comprising within its ever-growing boundaries about sixteen names which seem at times to be almost the despair of the chemical housekeeper who may wish to file away each element in its appropriate group-cupboard of the periodic system.

Notable among the aids to the worker in this field during the past few years have been the publication of Böhm's "Darstellung der Seltenen Erden," Leipzig, 1905, in two volumes of about 500 pages each, Schilling's "Vorkommen der Seltenen Erden," Munich, 1904, and Meyer's "Bibliographie der Seltenen Erden," Hamburg, 1905. Among the voluminous papers describing excellent work in this

[2] SCIENCE, N. S., Vol. XXVI., No. 670, pp. 569–74, November 1, 1907.

field by many distinguished chemists, we note in particular Urbain's recent separation of ytterbium into lutecium and neoytterbium, a separation previously indicated by Welsbach, and the still more recent work of James upon the bromate separation of yttrium earths, and the arrangement of the rare earth separation methods into a systematic scheme of analysis.[3] This latter piece of work certainly reflects great credit upon this painstaking investigator, and I will venture the prediction that if we keep our eyes upon Urbain and James we shall be rewarded by something more than mere spectacular spectroscopic speculations. Marc in a recent paper upon the "Development of our Knowledge of the Rare Earths and their Significance" calls attention in closing to a reference by Crookes to the rare earth minerals as a cosmic rummage chamber, and significantly adds that often the most important facts concerning the history of a family are to be found in rummage chambers.

Since thorium and zirconium are included by Böhm among the rare earths and are closely associated with them, these elements will be taken up at this point. The mention of thorium in this connection is certainly most appropriate, for it can not be questioned that the use of thorium nitrate in the preparation of the mantles used in incandescent gas lighting, and the development of this great industry have given a mighty impetus to the study of the rare earths.

A few figures will give us some idea of the growing importance of thorium and its chief mineral source, monazite. In 1902 the production of monazite sand in the United States and Brazil amounted to 3,500,000 pounds, with a value of $324,000; while the last report, that of 1906, shows a production of 10,450,000 pounds, with a value of $630,000—an increase in value of almost 100 per cent. In the United States alone, and almost exclusively from Henderson County, N. C., the value of monazite sand produced has increased from about $65,000 in 1902, to about $153,000 in 1906. Of interest and importance in this connection is the new mineral thorianite discovered in Ceylon in 1904. It carries from 70 per cent. to 80 per cent. of thorium oxide, and the report of 1905 shows an export of about 18,000 pounds, valued at about $24,000.

Helpful to the student of thorium are the works of Böhm and Schilling already mentioned, as well as the "Index to the Literature of Thorium" by Jouet, published by the Smithsonian Institution in 1903.

In considering zirconium we would note in particular the work of Rosenheim on the zirconyl salts and the investigations of Wedekind, who finds a practical method for the production of zirconium carbide, a compound resistant to air, water, and hydrochloric acid, and said to be an excellent conductor of electricity. Ninety parts of this carbide with ten parts of the metal ruthenium have been made by Sanders into filaments for use in the zirconium lamp. A mixture consisting of eighty-five parts of zirconium oxide and fifteen parts of yttrium earth oxides of the higher atomic weights is used in the manufacture of the Nernst glowers. The production of zircon in this country, much of it obtained as a by-product from monazite concentrates, has not been large; as reported in 1906 it amounted to 1,100 pounds, valued at $248.

In connection with the subject of rare earths it is perhaps of interest to refer to the growing use of ceric and cerous compounds as oxidizing and reducing agents; to Barbieri's statement in regard to cerium salts as catalytic agents, their behavior being similar to that of manganese

[3] *Jour. Amer. Chem. Soc.*, XXX., 979, June, 1908.

salts, and to Weiss's application of "misch metal," a mixture largely of the cerium earth metals, to the reduction of the oxides of Mo, V, Nb and Ta. Since cerium is obtained in large quantities as a by-product in the preparation of thorium salts from monazite, its various applications are of special interest.

Of the elements gallium, indium and thallium little will be said. During the past five years, gallium has been mentioned but once in the *Zentralblatt*, and that on account of its occurrence in a Sardinian blend. Renz and Thiel abroad and Mather in this country have done interesting work upon the properties and salts of indium. Indexes to the literature of these two elements, by Browning, were published by the Smithsonian Institution in 1904 and 1905. Thallium, with its two distinct conditions of oxidation and its ease of detection by means of its characteristic flame spectrum, has offered an attractive field to the student of pure chemistry. Growing interest in it is indicated by an increase of 200 per cent. in the number of reviews dealing with that element in the *Zentralblatt* for 1907 as compared with 1903.

Passing to group (4) we find besides thorium and cerium, already mentioned, the elements titanium and germanium. Germanium, like gallium, seems to have attracted little attention of late. An index to the literature of germanium, by Browning, was published in 1904 by the Smithsonian Institution.

Titanium can not be regarded as of rare occurrence, but I think that most chemists will allow it to be classed as a rare element under our definition. Hillebrand states that as far as his personal experience goes, titanium is entirely absent from no igneous, metamorphic, or sedimentary rock of a more or less siliceous character, and Clarke tells us that of 800 igneous rocks analyzed in the laboratory of the Geological Survey, 784 contained titanium. The element is now generally considered to stand tenth in order of abundance in the earth's crust as far as that has been explored, being more abundant than copper, lead or zinc. Considering these facts it is with satisfaction that we find titanium gradually taking its place among the useful elements. Until quite recently the presence of one per cent. or more of titanium in iron ores was considered sufficient to make them undesirable on account of the formation of pasty slags in the metallurgical process. This difficulty, according to Rossi,[4] can be avoided by judicious regulation of fluxes and temperatures. The addition of titanium to cast iron has been shown to increase its strength, and the presence of the same element in steel seems not only to augment the tensile strength of the steel but also to raise its limit of elasticity. This property of titanium has developed the production of ferro-titanium for use in the manufacture of steel.

According to the last volume of the "Mineral Resources," titanium is being used to a certain extent as a filament for incandescent electric lamps, and has the advantage over tungsten of a higher melting point and higher electrical resistance. Rutile, titaniferous magnetite, and titanium carbide are all finding some use as electrodes with carbon blocks in arc lamps. Other commercial uses of titanium are found in the employment of rutile for giving porcelain tile a yellow color and for coloring artificial teeth; of titanous chloride and titanous sulphate as mordants and of titanous potassium oxalate as a mordant and yellow dye in the treatment of leather. Recently we have seen quite frequent references to the applica-

[4] Rossi, A. J., *Trans. Am. Inst. Min. Eng.*, Vol. XXI., 832.

tion of titanous salts as reducing agents in volumetric analysis.

"Mineral Resources for 1906" reports a small production of rutile, chiefly from Virginia, as against no production in 1903; also large deposits of titaniferous iron ores from North Carolina, Wyoming and the Adirondack region. The constant advances made in the metallurgy of this element seem to assure an advancing prominence.

Passing to group (5) we find first on our list the element vanadium. Few of the elements which we have to consider are of such general interest. Its five distinct conditions of oxidation, with their salts, well-defined in most cases, furnish the chemist with a fascinating field for experimentation, as witness the many volumetric processes which concern themselves with this element, and the voluminous published work upon the salts of tetra- and trivalent vanadium.

Among the uses which have been found for vanadium are its employment in the making of a photographic developer, a fertilizer for plants, coloring material for glass, and with anilin, a black dye. Vanadyl phosphate has been found to behave physiologically like potassium permanganate. Vanadic acid (V_2O_5) is employed as a substitute for gold bronze, in the making of a water-proof black ink with tannic acid, in the manufacture of sulphuric acid by the contact process, and as a catalyzer to accelerate oxidation processes, such as the oxidation of sugar to oxalic acid, of alcohol to aldehyde, and of stannous to stannic salts.

Probably of more importance than any of these uses of vanadium is its employment in the manufacture of steel, as described in the pamphlets written by Mr. J. Kent Smith, of the American Vanadium Co. From these we learn of the remarkable elasticity and tensile strength of steels containing from .15 to .35 of one per cent. of vanadium introduced as ferro-vanadium, an alloy containing about 30 per cent. of vanadium. This important commercial use of the element has stimulated the search for its ores, a search which has resulted in our own country in several discoveries, chief of which is that of carnotite in Routt County, Colorado. Of interest in this connection are the extensive deposits of vanadium ore discovered in Peru less than two years ago, and found to contain a sulphide, essentially VS_4, named by Hewett patronite, and found by Hillebrand to contain from 18.5 per cent. to 19 per cent. of vanadium. Of value to the student of this element are three recent pamphlets, "Das Vanadin und seine Verbindungen," by Ephraim, 1904, "Die Literatur des Vanadins," by Prandtl, 1906, and "Le Vanadium" by P. Nicolardot, published by Gauthier-Villars, Paris.

Probably no one of the elements which we have to consider has made a more phenomenal leap from practical obscurity to comparative prominence than has tantalum. In the index of the *Zentralblatt* for 1903 we find no mention of this element, while the index for 1905, the year of the first application of tantalum to incandescent lighting contains twenty references to it. The use of the tantalum filament as a substitute for carbon is certainly an interesting step in the development of incandescent electric lighting. The tantalum lamp produces a light of one candle power for every two watts of electrical energy, as against three and one tenth watts required by the ordinary carbon filament. Tantalum is said to be as hard as steel and as resistant to chemical action as gold. These qualities are responsible for a patent for its use in pens.

A catalogue[5] of the mineral sources of

[5] *Zeitsch. f. angen. Chem.*, 1905.

the element, prepared by Schilling, shows over three hundred and fifty analyses of tantalum minerals comprising about forty species which occur widely distributed throughout the world. In our own country, South Dakota and Colorado reported a commercial production of the ores in 1906, and fair sized deposits have been found in North Carolina, Texas, and elsewhere. Last year ore carrying 80 per cent. of Ta_2O_5 was sold at from three to four dollars a pound. Since one pound of the metal will make some tens of thousands of lamp filaments, material for the new lights would seem to be plentiful and cheap.

Notable as a matter of purely chemical interest is the work of Edgar F. Smith and his associates upon the compounds of tantalum and columbium or niobium.

In Group (6) we have the elements Mo, W, U, Se and Te. Molybdenum, like vanadium, on account of its many well-defined oxidation stages presents interesting problems in analytical and synthetical chemistry; and the last half decade contains the record of considerable work upon the complex organic and inorganic compounds. The ores are in steady demand, chiefly for the production of ammonium molybdate, which is used in phosphate determinations, in fire-proofing, in coloring pottery glazes, and as a germicide. Molybdic acid is employed to some extent in dyeing. The metal is used in steels, but on account of its low fusing point can not be employed in filaments for incandescent lighting.

Few of the so-called rarer elements occupy so prominent a position at the present time as tungsten. Its production in this country alone has increased from about three hundred short tons, valued at about $44,000 in 1903, to over nine hundred short tons, valued at about $350,000 in 1907—an increase in amount of 200 per cent. and in value of 600 per cent. The principal source of tungsten ore in this country has been the deposits of wolframite in Boulder County, Colorado, while Arizona, Montana, New Mexico, Washington and Idaho have furnished some ore. Recently deposits of hübnerite in the Snake Range, Nevada, and of wolframite near Raymond, Cal., have been investigated. Ores are also mined in Europe, Africa, South America and Australia.

Without doubt, the most spectacular use of tungsten at present is in the filaments of the incandescent electric light bulbs. This metal with its melting point over 3,000° C., a little higher than that of tantalum, makes a lamp which has the advantage of giving one candle power of light per 1.25 watts of electrical energy, as against 2 watts in the case of the tantalum lamp, and which has a life of one thousand or more hours as against about five hundred hours for the carbon and tantalum lamps. The chief disadvantage of the tungsten lamp is the extreme fragility of the filament, which makes losses in transportation large unless the packing is very carefully done. Tungsten-titanium, tungsten-tantalum and tungsten-zirconium lamps have been recently suggested, but so far as I can learn they are still in the experimental stage.

Among the better and longer known uses of tungsten are its employment in ferrotungsten for the hardening of steels, and in sodium tungstate for fireproofing draperies and as a mordant in dyeing. Certain salts are also used in weighting silks. The high melting point of the element has suggested its possible use in the manufacture of crucibles.

Notable among the recent purely chemical work upon this element has been the study of the complex tungstates with titanium, zirconium and thorium, and the double polytungstates of alkali earths with the alkalies. The formation of the silicides of

molybdenum and tungsten by treatment with copper silicide or by fusing the oxides with silicon dioxide and aluminum is important. The interest which tungsten has aroused during the past five years is partly shown by an increase of 500 per cent. in the number of articles reviewed in 1907 over 1903.

Uranium and its ores, *i. e.,* pitchblende, carnotite, autunite, etc., seem to owe their chief prominence at present to the radioactive material associated with them, although uranium salts are used in the manufacture of certain velvety-black pottery glazes and greenish-yellow iridescent glasses. An interesting subject for further analytical work is the separation of uranium and vanadium in carnotite; a commercial process with this end in view has recently been developed by Haynes and described in the last volume of "Mineral Resources." The chief source of uranium in this country is the carnotite deposit of Colorado.

The element selenium has the peculiar property of being, under the influence of light, a fairly good conductor of electricity, while in the dark it is practically a nonconductor. In the latest edition of "Mineral Resources of the United States," Hess mentions the following purposes for which this property of selenium has been used in the construction of apparatus, namely: for automatically lighting and extinguishing gas buoys, for exploding torpedoes by a ray of light, for telephoning along a ray of light, for transmitting sounds and photographs or other pictures to a distance by means of telegraph or telephone wire, for measuring the quantity of Roentgen rays in therapeutic applications. Upon a more general demand for any or all of these instruments depends very largely the demand for selenium. Up to the present time there has been practically no production of selenium in the United States outside of small quantities existing in residues resulting from the refining of copper by electrolytic methods. The recent work upon selenium has been largely in the line of the formation of new compounds. A monograph by Marc[6] upon the "Physical and Chemical Properties of the Element" has recently appeared.

If the element tellurium had no other reason for prominence, its anomalous atomic weight and its mineralogical association with gold would serve to give it an important place. Lenher in a recent article has briefly discussed about forty years of combined work by Brauner, Baker and Bennett, Norris and himself upon the "Homogeneity of Tellurium," and has arrived at a conclusion in favor of homogeneity and of an atomic weight of 127.55. About the same time Marcwald reached a similar conclusion regarding homogeneity, but gave as the result of his work an atomic weight of 126.85, a value slightly below the accepted weight of iodine, 126.97. Marcwald's method was the heating of orthotelluric acid (H_6TeO_6) and the weighing of the tellurium dioxide obtained.

The close association of tellurium with gold has, as already intimated, brought about its possibly unenviable prominence. A careful study of the problems connected with the satisfactory handling of telluride ores has recently been published by Hillebrand.

One can scarcely speak of the growing prominence of such elements as gold and platinum, but a few figures in regard to their production in our country may be in point. The output of gold in 1906 was $94,000,000 as against $74,000,000 in 1903, and the output of platinum in 1906 was valued at $45,000 as against $2,000 in 1903.

[6] "Die Physikalisch-Chemischen Eigenschaften des metallischen Selens," Hamburg and Leipzig, Leopold Voss, 1907.

The value of the platinum imported in 1906 was nearly $4,000,000, or double the value of that imported three years earlier.

The platinum deposits in this country are to be found in Oregon, California, Washington, Utah and Nevada.

The separation and the complex compounds of the platinum metals continue to offer interesting problems to the chemist, and the able researches of Howe and of Gutbier have added much to our knowledge of this field. Palladium and iridium have found uses in the construction of fine apparatus. Osmium has long been used as a stain in microscopic work, and more recently as a filament for incandescent electric lamps. Ruthenium, as already stated, has been mixed with zirconium carbide for the filament used in the zirconium lamp.

In conclusion, allow me to refer to an address by Dr. H. Landolt given last November at the fortieth anniversary of the founding of the German Chemical Society upon the "Development of Inorganic Chemistry" during the past forty years.[7] In this address advancement along four lines was especially noted: (1) The discovery of the elements Ga, Sc, Ge, Sm, Gd, Tm, Eu, Nd, Pr, Ar, Xe, Ne, Kr and He; the discovery of radium; and the study of the phenomena of radioactivity, which has taught us that elements are undecomposed but not undecomposable bodies. (2) The realization of a compilation of international atomic weights, a work in which Dr. Clarke of the American Chemical Society has had a large and honorable share. (3) The preparation of elementary substances by the electric furnace and by the Goldschmidt process, and the study of allotropic modifications of elementary substances with special references to colloidal forms. (4) The formation of such compounds as the carbides, hydrides, silicides, complex acids and metal ammonium bodies.

[7] *Ber.*, XL., 4627, 1907.

In all of these lines of chemical progress, I am sure you will agree with me that the *rarer elements* have played an important rôle.

PHILIP E. BROWNING
YALE UNIVERSITY

SCIENTIFIC NOTES AND NEWS

THE Geological Society of America has altered the plan of holding its winter meeting at New Haven and will meet at Baltimore in convocation week in conjunction with the American Association for the Advancement of Science.

THE fourth annual meeting of the Southern Society for Philosophy and Psychology will be held in Baltimore during convocation week, December 28–January 2, in affiliation with the American Association for the Advancement of Science, the American Psychological and Philosophical Associations and other societies.

ON the occasion of the seventy-fifth anniversary of Haverford College, Dr. Theodore W. Richards, of the class of '85, professor of chemistry at Harvard University, gave an address entitled "The Relation of Modern Chemistry to Medicine." Professor Richards and Dr. James Tyson were among those on whom the honorary degree of doctor of laws was conferred.

PRESIDENT CHARLES R. VAN HISE, of the University of Wisconsin, received the degree of doctor of laws from Williams College on the occasion of the inauguration of President Garfield.

THE delegates from the United States to the International Conference on Electrical Units and Standards now in session in London are Dr. Henry S. Carhart, professor of physics at the University of Michigan; Dr. S. W. Stratton, director, Bureau of Standards, Washington, and Dr. E. B. Rosa, physicist of the bureau.

AT the general meeting of the German Meteorological Society at Hamburg in Sep-